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Reducing Waste in Residential Construction

1 July 2024 By Tien Peng

Feedback

By investing in waste reduction measures, a builder can combat labor shortages, save costs, meet timelines, increase productivity, boost profitability, and ensure client satisfaction.

Meanwhile, according to the Environmental Protection Agency, the construction of a typical single-family home generates an estimated 8,000 pounds of waste [i]. Pursuing affordable yet green materials and managing construction waste can improve the builder's bottom line and be an effective mechanism to lower the upfront costs for the owner, while increasing energy efficiency can reduce the homeowner's operational costs. Many of the techniques outlined below can be utilized by all designers and builders, large and small. A hundred years ago Sears Roebuck & Co. sold build-your-own kit houses for $2,000 (Figure 1)[ii] without the land. That home in 1920 is equivalent in purchasing power to about $31,407 today. Yet the national average cost to build a house today is about $329,000[iii], not including land. During that same era, the Ford Model-T automobile cost about $440, the equivalent purchasing power of $6,910[iv] in 2024. The current average cost of a new car in the U.S. is reported to be $47,433[v] . It costs ten times more to build a new home and only seven times more for a car.

FIGURE 1

Why is the building of a new home today more costly than the automobile? Of course, I am comparing different products, life cycles, technologies and regulations, but one major reason is **waste**. Over the years society has developed silos around architects, engineers, general contractors, trade contractors and specialty providers introducing significant waste into the delivery system. This waste includes various materials such as wood, drywall, metal, and cardboard but also time, labor, space, movements, and energy. Meanwhile, the automobile industry has been leading mass manufacturing for decades creating techniques to reduce waste, automation tools and safety innovations. Today, it still takes 120-180 days to build a home (automakers take about 18 to 35 hours to produce one vehicle[vi]). After the Second World War, Toyota pioneered the **Toyota Production System** (TPS)[vii] that would advance the manufacturing game in the following years. TPS focuses on reducing waste, creating customer value and seeking continuous process improvement. This is achieved by applying **Lean Principles** to eliminate waste or **Muda (無駄)** which refers to any activity that does not directly add value to the customer.

The Eight Wastes of Lean Production[viii] can be remembered by the acronym "DOWNTIME".

These can be applied to design, construction as well as the impacts of life cycle operations. The following provide examples that align with opportunities to reduce waste:

D – Defects (Design, Construction)

"Defects" leads to rework, one of the biggest causes of waste and a practice that commonly leads to projects being delivered late and over-budget. For the designer, the system of developing details with every new product specified is a potential area of "defect" waste. Not only do the detail sheets, plans, sections, and elevations need to reflect a new product but the field staff, inspectors and clients need to be updated.

Limiting variation and **Design for Assembly**[ix] (DFA)- Limiting **variation** is the key to reducing waste. For instance, limiting window sizes can benefit the architect or builder in terms of defects of design detailing, inventory, motion, communication, time to check detail, construction framing and extra processing. Do you need 8d common, 10d "short", or 8d box nail for your OSB shearwall application? DFA principles means working with the engineer to limit variation of the nails and/or develop a tighter nailing pattern so that the framer has one less decision to make goes a long way to limit "rework" when the inspection comes through. The fact that most custom home designs have up to thousands of variations of windows (or doors, nails, toilets, cabinets, etc) is very often a bias of the designer and not the homeowner.

O – Overproduction (Design, Construction, Operation)

Producing more than required or producing it too soon. Knowing what can be standardized and what must be customized is an important characteristic of reducing waste. Much of "overproduction" wastes originate with the design of the building form.

Shape: Most often a building's shape is determined by the shape of lot and zoning considerations. However, the shape of the building design can be a significant determinate of both the amount of construction waste as well as its life-cycle environmental impact. The more complicated the shape and façade articulation, the more opportunity for waste. By stacking the upper floor(s) over the main floor, the designer also optimizes the loading on the foundation and limits roofing. Vertical stacks and vents align better. Roof planes become easier to design. Understanding the standard dimensions of manufacture products (like carpet rolls, standard cabinets) all save money whether you are a small designer/custom builder or a large production builder.

Size: It is well known that the average size of an American home has increased over the last 100 years. In 1920's the average size of the home was 1,048 sf. The median home size peaked in 2015 at 2,467 square feet. The smaller the home, the less resources needed both in construction and long-term operations impact. One reason is architects are frequently paid as a percentage of the cost of construction. Bigger homes bring in more money.

W – Waiting (Design, Construction)

All too common is work-in-progress or people are waiting on the next step in production, waiting for the trade to complete their task. Wasted time waiting for the next step in the process to take place. By practicing a **Design for Assembly** (DFA) approach, the designer should consider simplicity and task-time requirements when they develop designs. Asking what it can prefabricate in the controlled environment of its lumberyard or factory rather than construct on site opens up improvements at construction sites. On the construction end, the most impactful tool is the **even-flow production**[x] which is a workflow-levelling strategy aims to decrease variability in the workflow for trades. There is not enough space here to fully describe this process, but the aim here is to analyze construction workflows, describe what task can be completed and optimally order the activity sequence by studying spacing and timing interferences to control variances to eliminate waste on the project.

N – Non-Utilized Talent (Design)

Communicate goals for design optimization. Seek contractor/supplier feedback to continuously improve designs and constructability reduces flow time, reduce cost, and Improve quality. Some of the innovations in the early 2000's came from continuous improvement with collaborations with lumber/manufacturer vendor to limit "overproduction" and "extra processing" wastes.

Advanced framing, also known as optimum value engineering (OVE), is a system of construction framing techniques designed to optimize material usage and increase energy efficiency[xi] . It is less expensive than conventional framing because it is more resource efficient than conventional framing and can cut floor and wall framing material costs by up to 30 percent while reducing installation labor. Back in the early 2000s, advanced framing was one of the first things that Quadrant Homes (a pioneering Seattle-based builder) did when it was still small (less than 50 homes/year). Paired the technique with the perforated shear walls (unique to western Cascades wind and seismic requirements) instead of segmented shear walls and you also save on hardware (again, also save time on installing the hardware in concrete). And there were synergies with energy efficiency as well, as the ratio of insulation (R-21) to stud (R-7) was greatly increased. Lastly, it allowed projects to increase the Grade of installation from III to I (because there are less interruptions by plumbing and electrical cut-outs).

Open-web floor trusses: These were pioneered in early 2000s, allowing faster and easier installation (Figure 2): The open space between the trusses' chords and webs allows for easier and faster installation of mechanical systems like plumbing, electrical, and HVAC trunk lines. The open web design also eliminates the potential dangers of drilling or cutting holes in solid joists. Open web trusses use smaller pieces of wood that are designed specifically for the job, which can result in less waste at the plant and on the jobsite. This and putting "ducts-inside" was a game-changer for energy efficiency and was featured in a study by the WSU Energy Program research as a model for energy efficiency.

FIGURE 2

T – Transportation (Design, Construction)

Unnecessary movement of material, data, and parts, inefficient transport, moving raw materials, parts, equipment, or information into or out of storage or between processes is a source of waste. Key waste reductions can be achieved through pre-fabrication. As much as can be manufactured in an enclosed factory is a way to eliminate site waste. The benefits are time savings, limits labor and space requirements on site, quality control and safety. This includes but not limited to walls, floors, stairs, and fireplaces.

I – Inventory (Design, Construction)

Inventory is one of the sources of waste for any project. There are anywhere from 400,000 to 500,000 pieces to a house[xii]. Keeping track of all the variation and sizes of studs, nails, paints, textures, windows, doors, faucets and cabinet pulls is a monumental task prone to error. Any opportunity to limit that complexity by limiting the variation eliminates errors in delivery, installation and payment. From a production standpoint, limiting the home to three or four window types/sizes is a standardization that still provides the required architecture aesthetic yet provides enormous benefits in eliminating waste. This reduces the necessary "Motion" as well (see below).

M – Motion (Construction)

Frequently on job sites workers are constantly shuttling back and forth across the site to grab materials or tools situated away from their workstation or regularly having to sift through material, or debris to find the parts they need. The way to eliminate this is through the 5-S Methodology[xiii]: seiri (整理) 'sort', seiton (整頓) 'set in order', seisō (清掃) 'shine', seiketsu (清潔) 'standardize', and shitsuke (躾) 'sustain'. Coordinating with the material vendors to deliver material in the sequence of installation as well as limiting extra material waste on site from "overproduction" reduces 'sorting' waste through material on the job site. Examples of 'setting in order' for equipment are labeling, sequencing, shadow board, color coding and ensuring supplies are stocked. Making sure there is a protocol for jobsite cleanliness ensure there is no build-up of hazardous, flammable or combustible materials remaining so workers can feel comfortable moving on site. Limiting the variability of the inventory prevents additional sorting motion on job sites. Having checklists ensure 'standardization' and communication. Engaging the workers and suppliers to understand the sources of "Motion" waste allows for 'sustaining' the self-disciplined mindset.

E – Extra Processing (Design)

Extra processing is the act of taking unnecessary steps in a process. Doing more work or higher quality work than your customer requires. Managing customer expectation is a key component of Lean Principles. Too often the designer or builder will impose their own bias on what is necessary for a home. Producing only what the customer wants, when the customer wants it reduces waste. Delivering value from the perspective and priorities of the end customer (are willing to pay not what they wish for) and are easy to produce from a lean perspective will reduce waste.

When running a business, it is common to keep efficiency in mind. Likewise, construction projects benefit from the reduction of waste from Lean Principles. With the increasing demand for housing and the need to address environmental concerns, there is tremendous value in optimizing to construction wastes. By investing in waste reduction measures, a builder can combat labor shortages, save costs, meet timelines, increase productivity, boost profitability, and ensure client satisfaction.

ENDNOTES

[i] https://www.epa.gov/sites/default/files/2015-11/documents/sfhomes.pdf
[ii] http://www.searsarchives.com/homes/1921-1926.htm
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[iv] https://www.in2013dollars.com/

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[xiii] https://asq.org/quality-resources/lean/five-s-tutorial

Tien Peng

GreenPlum Street LLC, Partner

Tien Peng is a Lean Six Sigma Black Belt and partner of GreenPlum Street LLC an ESG consultancy focused on decarbonizing the built environment. He was the Director of Architecture (1998-2010) for Quadrant Homes a subsidiary of Weyerhaeuser Corporation, that reconceptualized affordable housing in the Puget Sound. Quadrant advanced the Lean methodology with even-flow design and production that achieved a 54-day per home schedule at an average of $29/sf and was cited as a case study in the "The Elegant Solution: Toyota's Formula for Mastering Innovation" by Matthew May.

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